



EVs for EVs

The Basics of Electrified Vehicles for First Responders and Emergency Services

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Electrified Vehicles

- An **Electrified Vehicle** is *any* vehicle that...
 - Has an electrical energy storage device (batteries, ultra-capacitors, etc)
 - Is propelled by and/or recovers energy through an electric motor



Tesla Model S Powertrain (Dual Motor)

Image Source:
Tesla Model S Powertrain: Author

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Electrified Vehicles - Hybrids

- A **Hybrid Vehicle** is a vehicle where the powertrain is driven by a combination of an internal combustion (IC) engine AND an electric motor
 - Hybrid Vehicles automatically switch between IC-only mode, electric-only mode, or both the IC engine and electric motor providing torque to the drive wheels at the same time (also known as a 'Parallel Hybrid')
 - Vehicles with auto start/stop features (i.e. the IC engine turns off at a stop light) are considered 'Mild Hybrid Vehicles'

Parallel Hybrids:



Toyota Prius



McLaren P1

Mild Hybrids:



AMG E 53
(48V Mild Hybrid)



Chevy Malibu
Hybrid

Image Sources:

Toyota Prius: www.caranddriver.com/toyota/prius (22-Mar-2020)

McLaren P1: Author

Chevy Malibu Hybrid: www.caranddriver.com/reviews/a15100616/2016-chevrolet-malibu-hybrid-test-review/ (22-Mar-2020)

AMG E 53: https://www.motorauthority.com/news/1116478_2019-mercedes-amg-e53-mild-hybrid-arrives-in-late-2018-to-replace-the-e43 (23-JAN-2021)

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Electrified Vehicles - Electrics

- An **Electric Vehicle** is a vehicle where the powertrain is driven solely by one or more electric motors
 - Most commercially available electric vehicles are Battery Electric Vehicles (BEVs) since their drive energy is stored in a battery.
 - Some BEVs have internal combustion “range extenders” that recharge the battery *but do not connect to the drive wheels* (also known as a ‘Series Hybrid’)

Fully Electric:



Tesla Model 3



Chevy Bolt EV

Electric with IC Range Extenders:



Audi RS Q E-tron
(2022 Dakar Rally)



Chevy Volt

Image Sources:

Tesla Model 3: <https://www.caranddriver.com/tesla/model-3> (28-Mar-2020)

Chevy Bolt EV: Author

Audi: <https://hypebeast.com/2021/7/audi-rsq-e-tron-off-roader-2022-dakar-rally-model-revealed> (29-Jan-2022)

Chevy Volt: <https://www.caranddriver.com/chevrolet/bolt-ev> (28-Mar-2020)

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Electrified Vehicles – What YOU Care About...

**If it has an electric motor,
it is an Electrified Vehicle**



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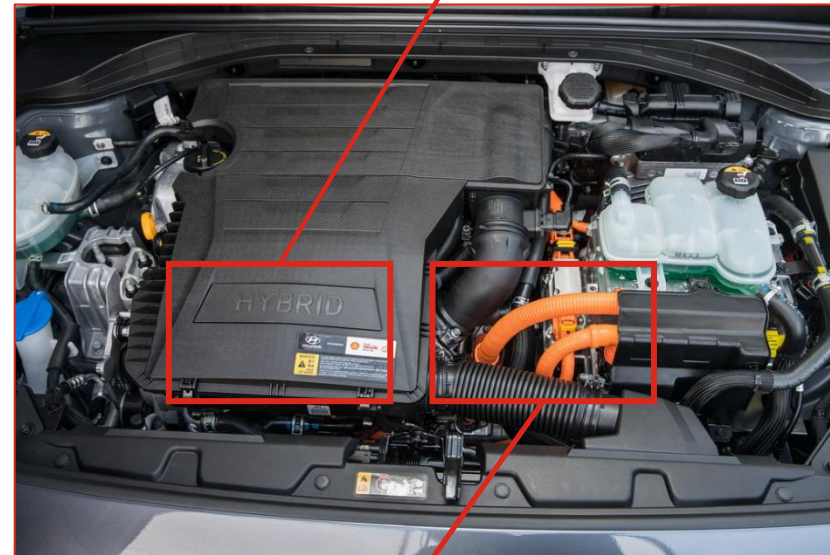


Identifying Electrified Vehicles

Tesla Badge



Badging or Markings



ISO 17480-4
Marker for High
Voltage Propulsion



Orange Conduit, Cables, or Connectors
(HV Cabling)

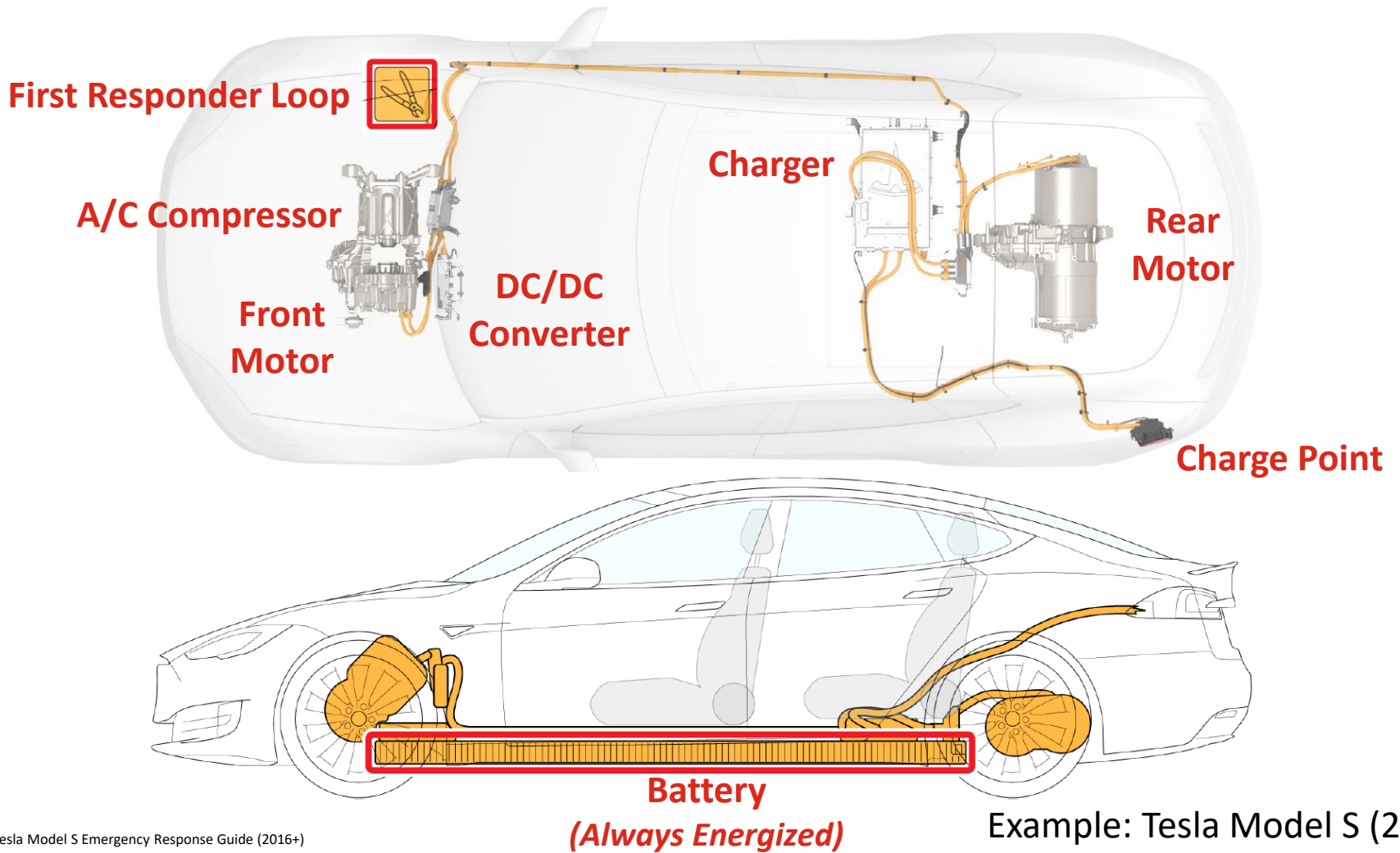
SCCA is working to standardize EV identification

Image Sources:

Tesla Model Y: <https://cleantechnica.com/files/2019/07/Tesla-Model-Y-White-Purple-Side-CleanTechnica-Kyle-Field.jpg> (23-JAN-2021)

Hyundai Ioniq: <http://www.cleanmpg.com/community/index.php?media/31672/> (23-JAN-2021)

Hazards – Electric Shock



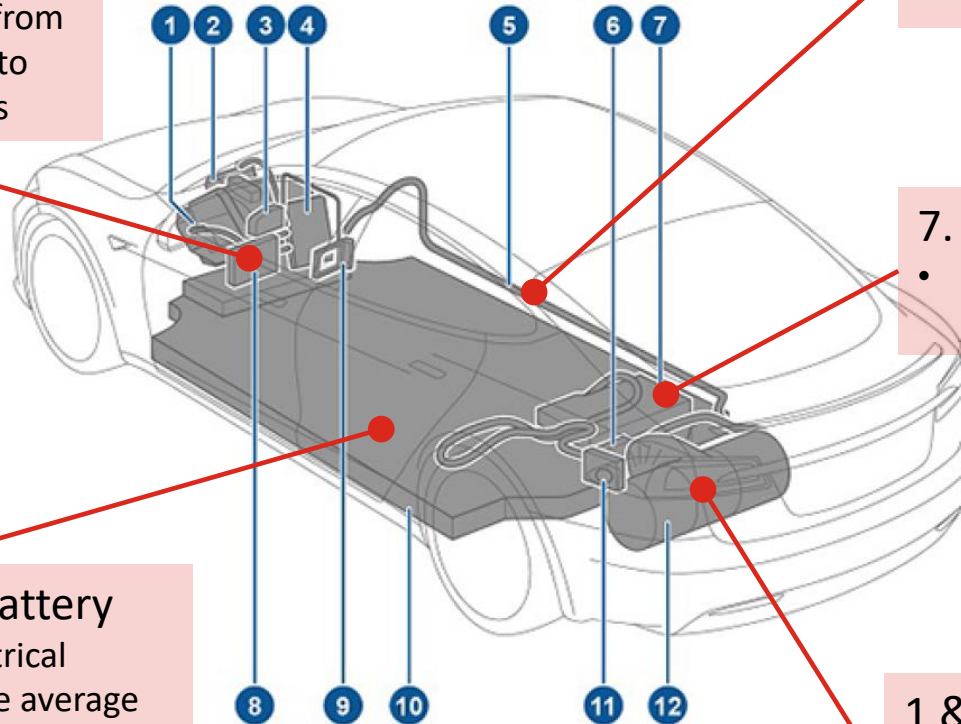
Example: Tesla Model S (2016+)

Source: Tesla Model S Emergency Response Guide (2016+)

Hazards – Electric Shock

8. DC-DC Converter

- Converts high voltage from battery to low voltage to power +12V LV systems



5. High Voltage Wiring

- Always ORANGE in color

7. Charger

- Charges battery from external power source

10. High Voltage Battery

- Stores enough electrical energy to power the average home for 1-3 days.
- Generally in floor of vehicle

1 & 12. Motors/Drive Units

- Converts electrical energy to torque on the drive wheels
- Multiple motors possible

Example: Tesla Model S (2016+)

Source: Tesla Model S Emergency Response Guide (2016+)

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Hazards – Electric Shock

- Tractive System (High Voltage) cabling is **ORANGE** in color
- Orange cables have special insulation and shielding to protect against electrical shock
- Always assume an orange cable is energized.
- Cutting an energized orange cable can be lethal!!!
- Do NOT assume that a “thin” orange cable is less dangerous than a “thick” one



NEVER CUT AN ORANGE CABLE IN AN EV!

Image Sources: <https://chargedevs.com/newswire/formula-e-attracting-new-powertrain-manufacturers-for-second-season/> (29-JAN-2022)

Hazards – Electric Shock

- Electrified Vehicles have multiple systems to prevent electrical hazards, even in a crash
 - Electrical energy isolated to inside the HV battery until vehicle is powered-on or a fault/crash is detected
 - In general, two or more electrical faults are required for vehicle to become a HV electrical hazard
 - There has been ZERO documented cases of electrical shock or transfer of electrical charge to a person in a crash¹
- Class 0 (1000V) Rubber Insulated Electrical Gloves help protect against electrical shock
 - Check condition daily prior to use
 - Periodic electrical re-test/re-certification is recommended.



Image Sources: <https://www.criticaltool.com/PHOTOS/media/catalog/product/irg-011-bk.jpg> (23-JAN-2021)

1: Dalrymple, Dave – SAE Board, Electric Vehicles. Web Video (1h 29 minute mark): <https://www.facebook.com/jason.defosse.3/videos/10159018776985575> (29-MAR-2021)

Electric Shock – What YOU Care About...

NEVER Cut ORANGE Cables!

**NEVER Cut Into High Voltage
Battery Compartments**

**When in doubt, wear
High Voltage Safety Gloves**

Hazards – HV Battery Fire



**ABC Fire
Extinguisher will
NOT put out a RESS
(HV Battery) fire**

Use ABC extinguishers to:

- Assist driver's egress of vehicle
- Extinguish brake fires
- Extinguish secondary fires (e.g. brush fires)

Image Sources:

<https://upload.wikimedia.org/wikipedia/commons/thumb/d/d9/FireExtinguisherABC.jpg/220px-FireExtinguisherABC.jpg> (23-JAN-2021)

<https://upload.wikimedia.org/wikipedia/commons/thumb/3/31/ProhibitionSign2.svg/150px-ProhibitionSign2.svg.png> (23-JAN-2021)

Hazards – HV Battery Fire



It may take an hour (or more) and several thousand gallons of water to extinguish an EV battery fire

In cases of RESS (HV Battery) Fire:

1. Ensure driver has egressed from vehicle
2. **DO NOT TRY TO EXTINGUISH VEHICLE FIRE**
 - Call local fire department
 - Keep a safe distance away
 - Extinguish secondary fires (e.g. brush fires)
3. Provide competitor's Emergency Services Guide to Fire Department for their reference in responding to fire
4. Move vehicle *only* once cleared by Fire Department to do so.
5. Store vehicle in an opened paved area (minimum 50 feet from any structure) for 24-48 hours prior to any transporting vehicle off-site

Always assume an Electric Vehicle fire is a HV Battery Fire

Fire Response Sources:

- NFPA's Alternate Fuel Vehicles Safety Training Program – 2015 Edition (pg 21 &22)
- Blanchette, Tom. Director of NHMS & Loudon Fire Department Captain. Email 27-APR-2016
- Model S Emergency Response Guide (2016+) (pg 23)

Image Source:

<https://caranddriver.com/news/a34335268/electric-car-fire-preparedness-ntsb-report/> (23-JAN-2021)

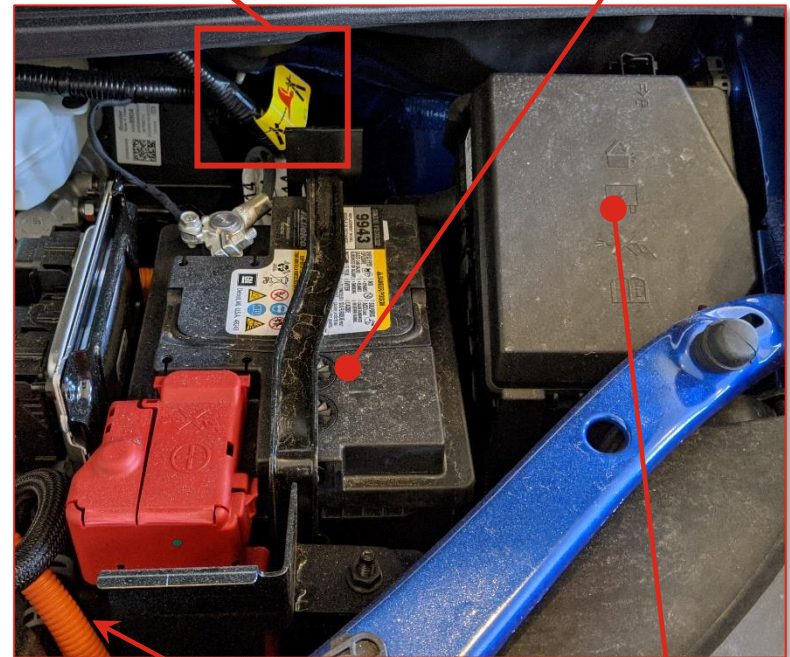
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Hazards – LV System/First Responder Loop

- Electrified Vehicles use a low voltage system for:
 - Occupant Safety Systems (e.g. airbags)
 - Interior/Exterior Lights
 - Enabling the HV System
- Many Electric Vehicles have a “First Responder Loop” to disable HV and occupant safety systems.
 - Cut loop prior to extrications
 - Perform ‘double-cut’ to remove section of loop and prevent inadvertent reconnection
- Emergency Services Guide will advise if first responder loop should be cut, the LV battery should be disconnected, or both

First Responder Loop

LV Battery



Orange Conduit
DO NOT CUT!

LV Fuse Box

Image Source:
2020 Chevy Bol EV: Author

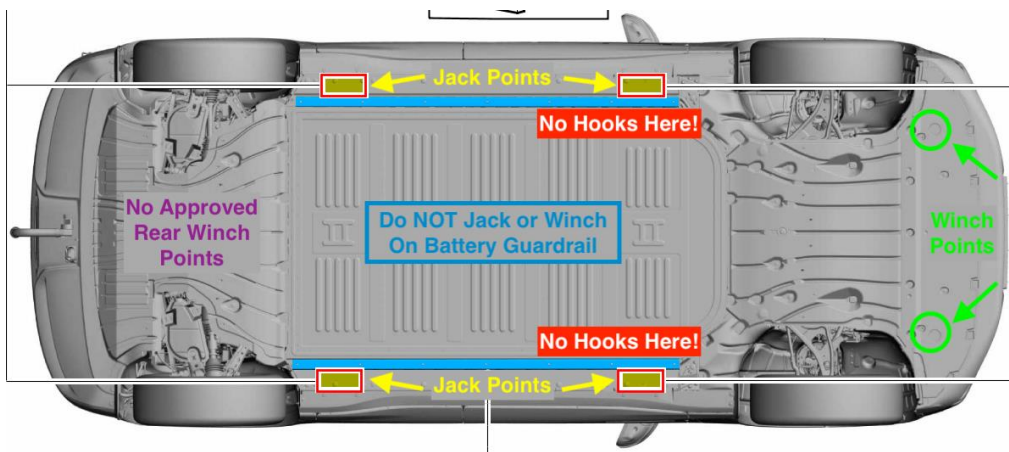
Hazards – What YOU Care About...

ALWAYS assume an Electric Vehicle fire is a HV Battery fire

Disable low voltage system prior to extrication

Winching/Jacking

- Care must be taken when winching/jacking an electrified vehicle
- Incorrect winching/jacking can result in breach of the RESS (HV Battery)
- Emergency Services Guide must illustrate dedicated winching/jacking locations



Only winch a vehicle from OEM winch points or GCR tow loops

Image Sources:

<https://insideevs.com/news/562050/flatbed-truck-damage-battery-report/> (29-JAN-2022)

<https://www.stableenergies.com/Rennline-Race-Tow-Hook-Universal/productinfo/REN-E01/> (29-JAN-2022)

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Towing

- NEVER flat-tow an electrified vehicle
 - Many electrified vehicles cannot disengage the wheels from the electric motor (even if in "Neutral")
 - Hazardous voltages can be generated with wheel spin resulting in component damage, overheating, or a vehicle fire
 - Many BEVs have motors connected to all four wheels



Only use a tilt-bed or dollies to tow electrified vehicles

Image Source: <https://insideevs.com/news/403116/evs-harder-tow-depends-manufacturer/> (23-JAN-2021)

Summary

- If it has an electric motor, it is an Electrified Vehicle
- NEVER cut orange cables
- NEVER cut into high voltage battery compartments
- ALWAYS assume an Electric Vehicle fire is a HV Battery fire
- ABC fire extinguisher will NOT put out a HV battery fire
- Disable low voltage system prior to extrication
- When in doubt:
 - Use High Voltage Safety Gloves
 - Refer to Moditech or manufacture-specific Emergency Field Guides for guidance



David Marcus drove a Tesla Model 3 to the B Street title at the 2019 Tire Rack SCCA Solo Nationals Championship (Photo Credit: David Cosseboom)

Image Source: www.scca.com/articles/2012724-second-set-of-2019-tire-rack-solo-nationals-champs-crowned (13-MAR-2021)

Resources

- Manufacturer-Specific Emergency Field Guides:
 - Tesla: www.tesla.com/firstresponders
 - Chevy: www.gmstc.com/index.php/first-responders/
 - Nissan: www.nissan.ie/ownership/nissan-services/first-responders-guide.html
 - General: www.nfpa.org/Training-and-Events/By-topic/Alternative-Fuel-Vehicle-Safety-Training/Emergency-Response-Guides
- www.evsaftytraining.org
 - NFPA Alternate Fuel Vehicle Emergency Field Guide (Updated 2018, Membership Req'd)
 - NFPA Alternate Fuel Vehicle Online Training for First Responders (Membership Req'd)
- Moditech (Membership Req'd)
- EV General:
 - WeberAuto: <https://www.youtube.com/user/WeberAuto>
 - Consumer Reports: <https://www.consumerreports.org/hybrids-evs/electric-cars-101-the-answers-to-all-your-ev-questions/>
 - Formula E: <https://www.fiaformulae.com/en/discover/cars-and-technology>